Spartan care, and living a remarkably busy life, it is but natural that Dr. Brinton should become a prominent figure of his times. His death creates a void that must long be felt; yet few American scientists have left worthier monuments in the form of finished works.*

W J M.

PRESIDENTIAL ADDRESS BEFORE THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.†

The presidency of a Society which embraces in its membership representatives of all the leading schools of engineering and applied science in this country is an honor which one may not lihgtly accept or indifferently bear. Although not established by its organic law, its traditions make it the duty of the presiding officer to present an address which should be, in spirit, at least, worthy of so important an occasion. Happily for those upon whom this honor may fall, custom has not yet restricted or defined the sphere of discussion which shall be thought suitable for such a paper; on the contrary, one may properly take advantage of this opportunity to become temporarily a *ronin*, a free lance, attacking everything and everybody, seeking only to give full and fair exposition of one's own personal, and, may be, peculiar views. This is the one compensation going with the burden which the Society insists must accompany the honors which it bestows. No apology is needed, therefore, for the selection of a topic the consideration of which may seem more or less irrelevant and unnecessary to some and, perhaps, unwelcome to others. In the present instance the choice is due to a strong conviction that schools of engineering are, for the most part, far from doing their full duty in an important matter, namely, the inculcation and dissemination of sound views, both theoretical and practical, relating to scientific metrology.

We cannot ignore the fact that the general public, even the intelligent public, receives its information regarding scientific and technical questions almost entirely from daily newspapers and popular magazines, than which, we will all admit, there could hardly be a more untrustworthy source. The widespread taste for sensationalism by which we are now cursed, a taste which seems to grow with the efforts made to satisfy it, offers a premium upon anything startling or revolutionary, giving little heed to sober, every-day truth. If one-tenth of the wonderful scientific discoveries that have been announced with glaring headlines in the public press within the last five years had *actually been made* it would, indeed, have been an epoch-making period; but, fortunately for everybody, they existed mostly in the brilliant imagination of the space writers who alone were benefited by their publication. If this were all we could afford to be indifferent, but there is the further disagreeable fact that a large number of intelligent people are led to look upon this sort of thing as real science, and few of us have an adequate conception of the extent of this delusion. One of the results is that in science, as in many other things, those who do the real work of the world fail to be credited with it, while the people are lavish in their praise of those whom they *believe* to be worthy. Only a few weeks since I found in an article on teaching history, written by the superintendent of schools in a large city, the names of a quartet of Americans most distinguished in war and peace. Three of the four were Washington, Lincoln and Franklin. As this is not meant to be a humorous paper, I will not mention the fourth, contenting myself with saying that in this instance the newspaper had done its work well.

*The portrait published as frontispiece is from a photograph taken in April, 1898, by F. Gutekunst, Philadelphia.

†Given at the Annual Meeting, Columbus, Ohio, August 17, 1899.

A curious and, in my judgment, a seriously instructive example of the readiness with which people accept newspaper science is found in the attempt made a year or two ago to fix the value of the ratio of the circumference to the diameter of a circle by legislative enactment. This incident may be familiar to some of you, but it is entirely worthy of consideration by those to whom is entrusted a large share of the instruction in exact science in American colleges. The legislative body involved was not one of a State south of Mason and Dixon's line nor west of the Mississippi River. It was a body chosen by the people of one of the greater States of the Union—one deservedly enjoying considerable distinction, especially in literary circles, on account of the eminent men it has produced, and also for the excellence of its educational institutions. In this Legislature, House, Bill No. 246 was entitled 'A Bill for an Act introducing a New Mathematical Truth,' * * * which truth, in the second section of said bill, turns out to be that the circumference of a circle is just $3\frac{1}{5}$ times its diameter. In the capital of the State is published a daily morning paper of unusual excellence. Not generally given to sensationalism, its contents are usually clean and wholesome, its news well collected and arranged, and even a single copy gives the impression that it is an example of the better phases of journalism. Yet this paper devoted more than two columns of its first page to an exploitation of this most important discovery, which had been made by a physician living in an obscure corner of the State. It was announced that the laws of the quadrature had been copyrighted and that this newspaper was allowed to be the first to make them public, this privilege being, without doubt, the bait which caught the uninformed editor. Some measure of his credulity may be found in his sober declaration that the circle-squarer's demonstration had been accepted by all eminent mathematicians; that the *American Mathematical Journal*, the highest authority in the country, had hastened to publish it, and this publication instantly attracted the attention of the scientific journals in Paris, the editors of which had eagerly sought contributions from the author of the discovery. The solution had been copyrighted in the United States and in England, Germany, Belgium, France, Austria, Italy and Spain. At Washington it had won the support of the professors of the National Astronomical Observatory, Professor Asaph Hall, 'whose fame was secure with the discovery of the moons of Mars' being specially delighted with it and finding in it a complete explanation of a hitherto unexplainable anomaly in the earth's motion. The desk of the discoverer was full of letters from leading mathematicians in Europe and America, and one from his agent in London proved that his demonstration had been shown to Tyndall and Huxley, who warmly endorsed its accuracy. Professors in Ann Arbor and from Johns Hopkins University had seen the demonstration and declared it perfect. I leave to the guardians of the name and fame of these institutions, and to others referred to, the task of ascertaining just what lineal descendant of Ananias was at that time on the editorial staff of this journal, but the actual disposition of the bill by the legislative body is a matter of much interest. When introduced, it was taken humorously by the Speaker of the House, who happened to be a graduate of a widely known educational institution, and he ordered its reference to the Committee on Swamp Lands. Two days later, however, the great discoverer had a hearing before the State Superintendent of Public Schools and the Committee on Education, who at once endorsed the solution; the Committee on Canals and Swamp Lands

reported House Bill No. 246 back, with a recommendation that it be referred to the Committee on Education; the latter Committee gave the bill careful consideration and reported 'the same back to the House, with the recommendation that the said bill do pass;' the bill was called up by the Committee and, *mirabile dictu*, the bill actually passed that branch of the Legislature, by what was reported to be a good, safe majority. Before it actually became a law, however, its character began to be recognized and its further progress was arrested. The possibility of such an incident at the very end of the nineteenth century is a fact from which some useful inferences may be drawn, and a just allotment of responsibility might well cause some anxiety.

But it is not to the particular kind of metrological reform suggested by this incident that I desire to ask your special attention. Josephus says that Cain 'broke the tranquility of the world by introducing weights and measures,' and it is perhaps not without significance that the first exponent of precise measurement was also the first homicide. At any rate, it will not be denied that the welfare of mankind has been enormously affected by the development of the art of weighing and measuring, and the importance of this art has grown with the perfection and complication of enlightened society. The systems of metrology in general use among English-speaking people at the present time have come to us from remote, almost pre-historic time, through Greece and Rome, and thousands of years have passed without any marked improvement in them, except in the betterment of fundamental standards, the interrelation of which is still as essentially illogical and unscientific as in the beginning.

As every one knows, the nineteenth century has witnessed a marvelous metrological reform among nearly all other races, and it is of this reform, never so important to us as just now, that I propose to speak. I am glad to assume in the beginning that you are all quite familiar with the general facts relating to this controversy, and I ask your consideration of the subject, not because of any lack of knowledge on your part, but rather because of my belief, already expressed, that you and the work you stand for have failed in a large measure, perhaps for lack of interest, in the active dissemination, among the general public, of the principles and advantages of a reformation of vital consequence to their material interests.

A brief review of existing conditions will be of use to those who have not given the subject serious thought. It is not generally known that the legal, fundamental standards of length and mass in this country are as numerous as the States of the Union. It will not do to say that these are identical, for they are not and cannot be, and many of their derivatives are decidedly different. There is a widespread notion that there is a United States standard pound which is everywhere legal, and a yard of the same authoritative origin, but this is an error, for these are only legal in transactions to which the general government is a party, and then only by authority of the Secretary of the Treasury. There is but one commodity which must everywhere be measured by one standard, and that is the coinage. And even this is nominally, not actually, referred to a material standard, legalized over seventy years ago, which is obsolete in form and construction, 'without pride of ancestry or (let us be thankful) hope of posterity.' Practically we ignore all legislation in the matter of fundamentals and universally accept standards of mass and length from two or three prominent makers who have mostly adopted those of the U. S. Office of Weights and Measures. There is much local legislation, however, on derived measures and much confusion results

therefrom. As an example, an act passed by the State of Massachusetts only five years ago may be cited. It legalizes *twenty-six* different bushels in one section, while in another it declares that a bushel *in heap measure* shall contain 2150.42 cubic inches, this being the volume of the well-known Winchester bushel when flat or struck, as used by the U. S. government and almost everywhere in this country. It also legalizes a dry gallon of 282 cubic inches, together with the liquid gallon of 231 cubic inches, which the government uses, thus creating an absolutely unnecessary but extremely annoying confusion. In one State there is a law that innkeepers "shall sell beer and ale by wine measure to all persons as drink it in their houses and by beer measure to all persons as carry the same out of their houses"; in another, and this in New England, it was enacted comparatively recently that in measuring certain commodities "one bushel and three quarters of a peck shall be deemed a bushel." In spite of legislation in many States fixing the value of a barrel at 31½ gallons, it contains in these same States almost invariably 40 or 42 gallons. In one State a gallon of milk must contain 231 cubic inches; in another its capacity is fixed at 282 cubic inches. Not only is the value of a bushel when determined by weight different for different commodities, but for the same commodity there is great variation among different States of the Union, amounting, in many instances, to fifty and seventy-five per cent. I need not consume your time in relating the many other inconsistencies and absurdities inherent in our present system, such as the variety of meanings attached to the word *ton*, not less than three or four in number; the confusion of pounds, ounces, etc.; the elusive and uncertain meaning of *perch*. With all of these and many others you are already familiar, and the whole system is so fearfully and wonderfully made that it may be safely affirmed that no man lives who knows and understands all of it.

Nor is it necessary for me to consider the origin and nature of the system which those interested in metrological reform wish to see installed in its place. Most, if not all, of you know it very well and have been accustomed to make use of it in a greater or less degree. The innumerable advantages of a system of metrology as simple and as scientific as that known as the metric system are now all but universally admitted. They have been written about and talked about and learned by actual use to such an extent that a presentation of them here would be a waste of time. I prefer to briefly consider a few of the more important arguments that have been made against this system or against its use in this country. There is a certain class of objectors, small in number, quite unworthy of serious consideration. Among them are those who see something sacred in the yard and the pound, because they are relics of antiquity, and something inherently wicked in the metre and the kilogramme because they originated with the French during the Revolution at the close of the last century. To some of them the very mention of the metric system is like a red flag to an anarchist, and two or three of them have published elaborate but tiresome arguments against the proposed reform, abounding in inaccurate statements and illogical and unscientific propositions. They mostly reveal a condition of intellectual atrophy over which it is but common charity to draw the veil of silence. There are, however, some criticisms of the metric system that are entitled to the most serious consideration on the part of its friends, and some of them are urged by those who would gladly welcome metrological reform if it came in a way which met their approval. The advocates of the metric system not only do not wish to

avoid rational criticism, but they heartily desire it, believing that the more widely it is known and discussed, the more its advantages are understood, the more enthusiastic supportors it will have.

One of the commonest arguments against it, one well known to all of you, I am sure, is that it is decimal and not duo-decimal or binary, or based upon some devisor other than ten. One may admit, for the sake of argument, that there would be advantage in subdividing a unit by continual bisections, but the extremely limited area to which this advantage would be restricted is almost universally overlooked. It is forgotten that it is only when measurements are the result of estimation or judgment that this superiority would be felt. This being admitted, it further follows that the exercise of judgment, wherein bisection may possess an advantage, occurs only when a single undivided unit is under consideration, and who will claim for a single instant that the difficulty of estimating a fraction of a unit is in the least dependent on whether that unit is itself the tenth or the eighth or the twelfth of another. The plain fact is that if one is contemplating the metre as a unit it is just as easy to think of or set off a half, quarter or eighth or sixteenth part as if it were a yard, and the same is true of the decimetre or centimetre when compared with the foot or inch. Indeed, one who is accustomed to use the metric system speaks and thinks of a half or quarter centimetre or a half or quarter millimetre without the slightest embarrassment, never imagining that he is in the least inconsistent or 'disloyal' to the decimal system. It is curious that this objection should be urged by people who have long ago become accustomed to a like condition of things in their currency and who would be extremely unwilling to go back to a system non-decimal in character. No one will pretend that the sub-division of a dollar offers any inconvenience and every one knows that the superiority of the decimal system in currency is so manifest that nearly all nations have adopted it in one form or another. Whatever disadvantages might be anticipated in the use of the dollar or the metre with decimal sub-divisions are involuntarily destroyed by the natural tendency to refer to smaller units rather than to continuous bisections. Thus we may talk of a half metre, or a quarter metre, but for smaller quantities the decimetre or the centimetre are at once chosen, and when we wish to go below a half of a cetimetre the millimetre offers itself as a convenient unit. In the same way we find no embarrassment in taking up the cent as a unit when it is desired to go below a quarter of a dollar. That the several units thus used are decimally related to each other is the one fact that makes all of this beautiful simplicity possible. I have ventured to elaborate somewhat on this point because many people are of the opinion that the fact that the radix is ten and not two is a really serious objection to the metric system. It is believed, however, that careful study of the principles involved, following the lines indicated above, will show that this fact is of no importance. And it must not be forgotten that our present system is anything but binary and that the adoption of almost any radix would be an enormous improvement. But, above all of this, it must be remembered that nobody claims any special virtue or unique qualities for the number *ten*. It is not because it is decimal that the metric system is so far superior to all others. The superiority rests upon two great facts, the first of which is that the radix of the system is identical with that of the system of notation and numeration now and for many years in use by all civilized people. It may well be that a binary or duodecimal or some other system of notation would offer advantages over that which has prob-

ably fixed itself upon us for an indefinite future, but it is absurd to argue that metrological form must wait upon a notational revolution. The probability of the latter is almost infinitely small, at least for centuries to come, while already a majority of civilized nations have adopted the decimal system of weights and measures. The other great fact on which the superiority of that system depends is the beautifully simple inter-relation of units, resting upon constant physical properties of matter. No other system is for a moment comparable with it in this respect, and this alone would entitle it to consideration and adoption by all progressive communities. I pass over many more or less trivial objections to the metric system, all of which have been successfully answered many times, to take up one which is of far greater importance than all others, although it is not really a fault in the system itself. It is urged that the adoption of the system in this country must be accompanied by very large loss, especially among machinists and manufacturers, of accumulated material in the form of tools, machines, patterns, etc., which have been designed and made upon a basis of the foot or inch unit of length and which would be rendered useless by the introduction of the metre or centimetre. It is also argued that there would be great loss occasioned by the disuse of scales, balances, weights, etc., which would necessarily be replaced by metric measures. On these grounds several very able engineers have based a strenuous opposition to the proposed reform, and their influence is freely admitted to be the most serious obstacle to its progress.

Against this argument a few incontrovertable facts are put. One of these is that only a relatively small proportion of tools and machines are in any way effected by the question of standards; another is that the life of a tool or machine in these days is comparatively short, not only on account of deterioration from use, but as well because of continual improvements which render designs only a few years old practically worthless. Much has been said about the enormous value of patterns for machinery and machine tools which have accumulated during a period of years and which would be rendered useless by the introduction of new standards. Concerning this it may be said that in many of the most extensive manufacturing establishments in this country patterns once used are not considered as assets at all, the chances being that, through the rapid improvement in design constantly going on, they will shortly become obsolete. There is also the further fact, testified to by some important establishments in which the metric system has already replaced the old, that there is almost invariably enough to spare in a casting which is to be machine finished to make it possible to work it to metric dimensions. In a similar way the possible cost of the reform due to the necessary change in apparatus and standards for weighing and measuring has been grossly overestimated. Balances will be, of course, not affected at all; platform and other scales can readily and cheaply be adapted to the new units. Those who have maintained a somewhat bitter opposition, based on this question of cost, to all suggested legislation looking to metrological reform, seem to have ignored two important considerations; the first is that the thing which they proclaim to be so difficult that it is practically impossible has already been accomplished and many times, by different European nations with almost no difficulty and under conditions vastly less favorable than those existing with us. The second is that no reasonable advocate of the metric system expects the transformation to be made in a night or in a month or a year. The history of the adoption of

our currency system furnishes a useful example of what may be expected. More than a generation elapsed after it became the legal system of the nation before its use was even approximately universal.

There is another objection to the metric system important enough to deserve examination, and that is the alleged difficulty of understanding it and of becoming accustomed to its use, and it has been affirmed that this difficulty would be especially marked among mechanics and workmen of all classes who make frequent use of weights and measures. Here, again, we may best appeal to experience. To Germany, Austria, Italy, Spain and other European nations outside of France the metric system came as a foreign innovation, but nowhere was any serious difficulty experienced. The same may be said of practically every nation on the American continent, excepting the United States and Canada. Before a Parliamentary Committee, Siemens testified concerning its introduction in his own works in Germany, that "it was all a matter of about a fortnight or three weeks; then the people were accustomed to it and did not ask for any more of the old measures, but asked for the new." In Germany the Adopting Act was passed in 1868, and the use of metric measures was made compulsory in 1872. Siemens testified that this actual adoption took place mostly between January 12, 1870, and January 1, 1872, and that when the compulsory time came there was nobody to be compelled. Other German testimony was of the same character, that knowing they had to be ready when the time came they were ready before the time came. Professor Foerster, Chief of the German Bureau of Weights and Measures, under whose direction the introduction of the metric system was made, has furnished us a most interesting account of how it took place. In speaking of the complaint, then common in Germany, as it has been here, that the metre was too long, that "we can estimate by the foot and not by the metre," he makes the very suggestive remark that "experience has shown that here too many people have only hung a cloak around habit in order to hide its nakedness." You are doubtless all aware that a few years ago in the great English engineering establishment of Willans & Robinson the metric system was adopted to the entire exclusion of British measure. Their testimony is strongly in its favor and shows that English workmen very quickly adapt themselves to its use, and when once they understood it all agreed that it was much easier to work to than the English system. The head of their tool room testified that "it was a little awkward for a time," but this lasted only about two days. Some of our own large manufacturing establishments having branches in Europe, such as the General Electric Company, have declared that they found a decided advantage in making and working to metric drawings. Indeed, there is an 'embarassment of riches' in testimony of this kind, and I feel that I ought rather to apologize for bringing any of it before this body. We may justly regard the case as proven and the controversy closed, except as to the question of ways and means. If it be affirmed that there is no demand for the change I could deluge the Society with resolutions of chambers of commerce, boards of trade, manufacturers' associations, engineers' clubs and societies, builders' exchanges, architects' clubs, pharmaceutical associations, trades unions, educational and scientific bodies and other public organizations too numerous to even name. In England the past five years have witnessed what is little short of a revolution of sentiment on this question, the result of an agitation originating not among scientific men, but with the so-called practical people. It is there, as it must soon be here, a question

of vital importance to commerce and trade. The testimony of their far-sighted consular agents in various parts of the world is that British trade with all nations except our own is sadly handicapped by its units of measure, and our own consular reports are of the same tenor. Within a year we have entered upon a new era in our foreign relations. Our trade with foreign nations has increased enormously and must increase still further if we are to maintain our footing. We have already absorbed a considerable population by whom the metric system has long been used, and our merchants and manufacturers are already feeling the disadvantages of our antique and irrational measures of quantity. Fortunately for us, our principal competitors are the English, who are carrying nearly the same burden. But they have been quick to recognize the necessity for reform and in five years they have made more progress towards it than we have in thirty.

Schools of engineering and professors of engineering and applied science can do more, if they are so minded, to help their country in this emergency than any other agency that I know of. They can do it by a more liberal use of the metric system in their daily work. Electrical engineering, by a wonderful stroke of good fortune, emancipated itself from this curious slavery in the very beginning, and its astonishingly rapid growth from infancy to the vigorous manhood which it now enjoys is very largely due to that fact. In the engineering college of to-day the student in physics and chemistry is brought into close relations with the metric system, but when he advances to his professional studies in civil and mechanical engineering he is too often compelled to relapse into the exclusive use of the foot, the pound and the gallon. I am far from recommending the abandonment, at this time, of these useful units, but I strongly urge the importance of allowing them to share their work with their metric analogues and very liberally. Even if there were no other advantage there would be an enormous gain to the student in compelling him to do his problems and his laboratory exercises in more than one system of units, than which nothing contributes more to clearness of understanding and soundness of knowledge. If we had begun this a quarter of a century ago and kept it up we should be in much less danger of being beaten in the race for the markets of the world than we are to-day; for this system is bound to become universal and in the near future. The prodigious advantages which it offers in its simplicity, its economy and its already extensive use will insure this. No body of men can more effectively influence public sentiment to an appreciation of this fact than those I now address.

One of the ablest and most scholarly arguments in favor of the metric system ever made was that of Charles Sumner in the Senate of the United States more than thirty years ago. He summarized the argument as follows: "A system of weights and measures born of philosophy rather than chance is what we now seek. To this end old systems must be abandoned. A chance system cannot be universal. Science is universal; therefore, what is produced by science may find a home everywhere."

T. C. MENDENHALL.

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*WORK OF THE U. S. GEOLOGICAL SURVEY.**

APPROPRIATIONS for the work of the U. S. Geological Survey for the current fiscal year amount to $806,000 as against $816,000 for the preceding fiscal year. The apparent decrease is largely because of special items appropriated in the former year, one of which, for printing and binding monographs, amounted to $40,000. The amounts for

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